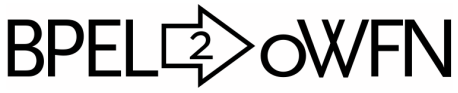

Translating BPEL Processes into Open Workflow Nets
GNU BPEL2oWFN Version 2.4, 24 January 2010

Niels Lohmann

About this document:

This manual is for GNU BPEL2oWFN, version 2.4, a tool translating a BPEL process into an open workflow net (oWFN), last updated 24 January 2010.

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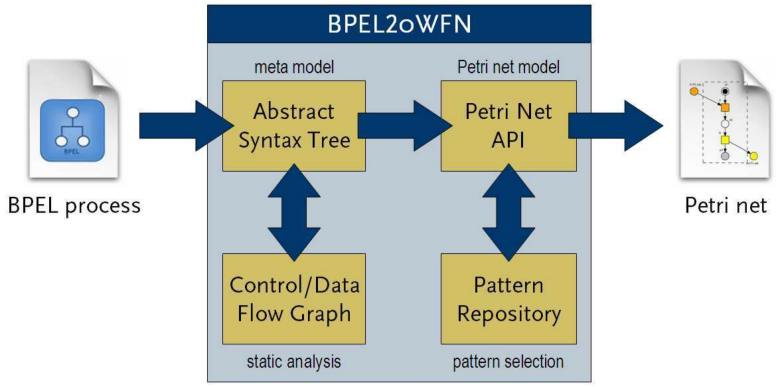
1 Introducing BPEL2oWFN

BPEL2oWFN translates a web service expressed in WS-BPEL (Web Service Business Process Execution Language) into an oWFN (open Workflow Net). This oWFN can be used to:

- check for *controllability* or generate the *operating guideline* using the tool Fiona[1],
- check for deadlocks or any other Petri net property, or
- check any temporal logic formula with a variety of model checking tools.



Furthermore, BPEL2oWFN can translate a BPEL4Chor choreography to a Petri net model. This model can be used to analyze properties of a complete choreography or to synthesize a fitting service for an incomplete choreography.

BPEL2oWFN uses static analysis to make the generated Petri net model as compact as possible to analyze a chosen property. This is called *flexible model generation*. Furthermore, several design flaws can be detected using control and data flow analysis.

BPEL2oWFN was written by Niels Lohmann, Christian Gierds and Martin Znamirowski. It is part of the Tools4BPEL project funded by the Bundesministerium fr Bildung und Forschung. See http://www.informatik.hu-berlin.de/top/tools4bpel for details.

1.1 Concepts of BPEL2oWFN

Input BPEL Process — BPEL2oWFN can read BPEL processes compliant to the WS-BPEL 2.0 or the BPEL4WS 1.1 specification.

Abstract Syntax Tree — The AST (abstract syntax tree) is the main data structure of BPEL2oWFN. The AST is annotated with information gained by static analysis.

Control/Data Flow Graph — From the abstract syntax tree, a control/data flow graph is built. This graph is used to apply static analysis algorithms to gain information (e.g., dead code) about the process. These algorithms Furthermore, design flaws such as cyclic control links or conflicting receiving activities are detected.

[1] Fiona is available at http://www.informatik.hu-berlin.de/top/tools4bpel.

Petri Net API The annotated abstract syntax tree is used to generate a Petri net model of the BPEL process. All Petri net-related functions (adding, removing and merging of nodes; structural reduction) are provided by the Petri net API (application programming interface).

Pattern Repository For each BPEL construct, several patterns with different degrees of abstraction are stored in the pattern repository. Using the information gained by static analysis, the most abstract pattern applicable is used.

Output Petri Net The generated Petri net model can be exported to many file formats, such as PNML, LoLA, Fiona oWFN, INA, APNN, or PEP.

2 Setup and Installation

The distribution environment of BPEL2oWFN was created using the GNU Autotools. If you are familiar with the setup and installation procedure of any GNU tool you may skip this section.

2.1 Setup

To setup the installation environment and to compile BPEL2oWFN simply follow these steps:

1. Unpack the source tarball by entering[1]

   ```
   gunzip bpel2owfn-2.4.tar.gz
   tar xf bpel2owfn-2.4.tar
   ```

2. Enter that directory:

   ```
   cd bpel2owfn-2.4
   ```

3. Run the configure shell script which attempts to guess correct values for various system-dependent variables used during compilation. It uses those values to create a '`Makefile`' in each directory of the package. Entering

   ```
   ./configure
   ```

   should lead to an output like:

   ```
   checking for a BSD-compatible install... /usr/bin/install -c
   checking whether build environment is sane... yes
   checking for a thread-safe mkdir -p... /usr/bin/mkdir -p
   checking for gawk... gawk
   checking whether make sets $(MAKE)... yes
   checking build system type... i686-pc-cygwin
   checking for g++... g++
   checking for C++ compiler default output file name... a.exe
   checking whether the C++ compiler works... yes
   checking whether we are cross compiling... no
   checking for suffix of executables... .exe
   checking for suffix of object files... o
   checking whether we are using the GNU C++ compiler... yes
   checking whether g++ accepts -g... yes
   checking for style of include used by make... GNU
   checking dependency style of g++... gcc3
   checking for gcc... gcc
   checking whether we are using the GNU C compiler... yes
   checking whether gcc accepts -g... yes
   checking for gcc option to accept ISO C89... none needed
   checking dependency style of gcc... gcc3
   checking how to run the C preprocessor... gcc -E
   checking for grep that handles long lines and -e... /usr/bin/grep
   checking for egrep... /usr/bin/grep -E
   checking for ANSI C header files... yes
   checking for sys/types.h... yes
   checking for sys/stat.h... yes
   checking for stdlib.h... yes
   checking for string.h... yes
   checking for memory.h... yes
   checking for strings.h... yes
   checking for inttypes.h... yes
   ```

[1] Cygwin users should open a `tcsh`-shell before.

```
checking for stdint.h... yes
checking for unistd.h... yes
checking windows.h usability... yes
checking windows.h presence... yes
checking for windows.h... yes
checking for pow... yes
checking whether gcc and cc understand -c and -o together... yes
checking for bison... bison -y
checking for flex... flex
checking lex output file root... lex.yy
checking lex library... -lfl
checking whether yytext is a pointer... yes
checking for kc++... kc++
checking for dot... dot
configure: creating ./config.status
config.status: creating Makefile
config.status: creating doc/Makefile
config.status: creating src/Makefile
config.status: creating src/Doxyfile
config.status: creating tests/Makefile
config.status: creating rpm/Makefile
config.status: creating rpm/bpel2owfn.spec
config.status: creating src/bpel2owfn.h
config.status: executing depfiles commands
```

In some cases the configure script complains (i.e. warns) about tools which could not be found in your system path. In this case please check [Tool Dependencies], page 6. BPEL2oWFN can be compiled without these tools. However, you cannot make changes to large parts of the programm as you will not be able to generate source files without the tools.

4. After all Makefiles are created, run

```
make
```

to compile the executable binary as well as a documentation file.

5. Alternatively, you can run

```
make check
```

to self-test the created binary. After many lines of output[2] `make check` should announce

```
==================
All 6 tests passed
==================
```

or, if anything went wrong, prints error message and requests to report the encountered bug to bug-bpel2owfn@gnu.org.

2.2 Installation

After successful compilation and self tests an executable file '`bpel2owfn`' (or '`bpel2owfn.exe`' on systems running Microsoft Windows) is created in the directory '`bpel2owfn-2.4/src`' of the distribution. This file has no dependencies to other files of the distribution and can be copied to any directory.

Alternatively you can install BPEL2oWFN properly by executing[3]

[2] Unless the test script displays error messages warnings of BPEL2oWFN can be ignored.

[3] Usually, '`make install`' and '`make uninstall`' can only be executed by the root user.

```
make install
```

to copy the binary to the directory '`/usr/local/bin`' and to make the documentation accessible (i.e. copy it to '`/usr/local/info`') for

```
info bpel2owfn
```

You can undo the installation by entering

```
make uninstall
```

The setup and installation procedure can be customized by running `./configure` with several command-line options. Type

```
./configure --help
```

for more information.

2.3 Problems during Setup or Installation

Any warning during an in other respects successful compilation can be ignored — these warnings mostly occur in generated files from Flex, Bison or Kimwitu++ and are outside of our scope.

The compilation of BPEL2oWFN was tested on several operating systems such as Microsoft Windows (running Cygwin), GNU/Linux, Apple Mac OS X and Sun Solaris. Anyway, if the compilation fails please make sure you use the most recent (stable) versions of the GNU Compiler Collection. If this does not help please send us an electronic mail to bug-bpel2owfn@gnu.org. Include the version number of your distribution (version 2.4 of 24 January 2010). Also include in your message the output that the make process produced. We will try to answer your mail within a week.

If you are not interested in compiling BPEL2oWFN yourself you can alternatively download executable binaries for several operating systems on the website of BPEL2oWFN (http://www.gnu.org/software/bpel2owfn).

2.4 Makefile Targets

The generated Makefiles serve different targets:

`all`

Compile BPEL2oWFN and create an executable binary '`bpel2owfn`' (or '`bpel2owfn.exe`' on systems running Microsoft Windows) in the directory '`bpel2owfn-2.4/src`'.

`dvi`
`html`
`pdf`
`ps`

Generate documentation files in the given format which can be DVI, HTML, PDF or PostScript. The documentation is generated in the directory '`bpel2owfn-2.4/doc`' and is named '`bpel2owfn.`*`format`*' (User's Manual).

`clean`

Clean all temporary files created during the compilation. Executables as well as generated documentation are preserved.

`distclean`
: Clean also source files generated by the compiler generator tools (Flex, Bison and Kimwitu++). Executables as well as created documentation files are also removed. Before re-compilation you have to run '`./configure`' again. Please note that after running '`make distclean`' you need the tools described in [Tool Dependencies], page 6 to compile.

`check`
: Perform a number of self-tests: the directory '`tests`' contains several BPEL processes which are read and compiled.

2.5 Tool Dependencies

2.5.1 Required Programs

To compile BPEL2oWFN you do not need any specific program other than the GNU Compiler Collection. If you however want to change the program (e.g. add new Petri net patterns) you need the following programs to generate source code. These programs are (as BPEL2oWFN itself) free software distributed under the GNU General Public License.

Flex, A fast scanner generator
: Flex is needed to generate the lexer of BPEL2oWFN. Flex was written by Vern Paxon. Copyright © 1990 The Regents of the University of California. All rights reserved. Flex is available under http://www.gnu.org/software/flex/flex.html.

Bison, The YACC-compatible Parser Generator
: Bison is needed to generate the parser of BPEL2oWFN. Bison was written by Robert Corbett und Richard Stallman. Copyright © 1992, 1998, 1999, 2003, 2004, 2005 Free Software Foundation, Inc. Bison is available under http://www.gnu.org/software/bison/bison.html.

Kimwitu++, The Term Processor
: Kimwitu++ is needed to generate all files managing the AST (abstract syntax tree). Kimwitu++ was written by Toby Neumann and Michael Piefel. Copyright © 1988-1997 Axel Belinfante, University of Twente. Copyright © 1997-2007 Michael Piefel, Humboldt-University Berlin. Kimwitu++ is available under http://site.informatik.hu-berlin.de/kimwitu++.

2.5.2 Optional Programs

BPEL2oWFN is a compiler and thus creating output files which can be read by several other programs. These programs are not needed to compile BPEL2oWFN yet without these programs BPEL2oWFN makes not much sense.

LoLA, a Low Level Petri net Analyzer
: LoLA is an explicit model checker implementing a broad variety of reduction techniques such as partial order reduction, symmetries or the sweep line method. LoLA was written by Karsten Schmidt and is available under http://www.informatik.hu-berlin.de/~kschmidt/lola.html.

Graphviz, the Graph Visualization Software
: Graphviz is a graph visualization software with several graph layout programs including dot. Graphviz is maintained by AT&T Labs and is available under http://www.graphviz.org.

The Graphviz tool dot can be used to create a graphical representation of the generated Petri net in PNG (Portable Network Graphic) format. If dot is not found on your system, BPEL2oWFN will only create a .dot-file and does not try to invoke dot.

2.5.3 Supported Platforms

BPEL2oWFN is implemented in ANSI C and ANSI C++ and should compile on nearly any platform that supports the GNU Compiler Collection.

However, we tested BPEL2oWFN on these platforms:

- Microsoft Windows 2000 (x86)
- Microsoft Windows XP (x86)
- Microsoft Vista Business (x86)
- Apple Mac OS X Tiger (Universal: PowerPC and x86)
- Sun Solaris 8 (SPARC)
- Sun Solaris 9 (SPARC)
- GNU/Linux (x86)

2.5.4 Reference System

As of January 2010, we use the following system developing and building BPEL2oWFN:

- Apple MacBook
- 2 GB RAM
- Mac OS X 10.4.10 (Tiger)
- GNU Compiler Collection 4.0.1 (Apple Computer, Inc. build 5367)
- Flex version 2.5.33
- GNU Bison version 2.3
- Kimwitu++ version 2.3.11

The version numbers are not to be understood as system requirements, but as a help if you fail to compile the sources.

3 Invoking BPEL2oWFN

The standard invocation of BPEL2oWFN is:

```
bpel2owfn -i service.bpel -m petrinet -f owfn -o
```

where '`service.bpel`' is a BPEL process. The option '`-f owfn`' causes BPEL2oWFN to generate an open workflow net (option '`-m petrinet`'). This net is written to a file named '`service.owfn`', because of the option '`-o`'.

BPEL2oWFN can be called without any parameter. In this case, it acts as a simple parser for BPEL processes that reads its input from the standard input (`stdin`).

3.1 Options

BPEL2oWFN supports the following command-line options:

'`--help`'
'`-h`' Print an overview of the command-line options and exit.

'`--version`'
'`-v`' Print version information and exit.

'`--input=`*`filename`*`.bpel`'
'`-i` *`filename`*`.bpel`'
Read a BPEL process from file '*`filename`*`.bpel`'. If this parameter is omitted, input is read from standard input (`stdin`). Wildcards such as '`process*.bpel`' are also allowed.

'`--wsdl=`*`filename`*`.wsdl`'
'`-w` *`filename`*`.wsdl`'
Read a WSDL file to support the translation.

'`--topology=`*`filename`*`.xml`'
'`-t` *`filename`*`.xml`'
Read a BPEL4Chor participant topology file to support the translation of BPEL4Chor choreographies. Can only be used with the '`choreography`' mode.

'`--output[=`*`filename`*`]`'
'`-o`' The generated output is written to a file called *filename*. If the short form is used or the *filename* is omitted, the input file name is taken and extended by the suffix of the chosen file format(s). If this parameter is omitted, the output is passed to the standard output (`stdout`).

'`--log[=`*`filename`*`]`'
'`-l`' All additional information like warnings and processing information are written to a file called *filename*. If the short form is used or the *filename* is omitted, the output file name is taken and extended by the suffix '`.log`'. If this parameter is omitted, the information is passed to the standard error output (`stderr`).

'`--debug=1-4 | flex | bison`'
'`-d 1-4 | flex | bison`'
This option triggers different debug levels, and can enable additional information from Flex and Bison about how the input is lexed and parsed.

Debug level:

‘0’ When errors are found, only display the error code and skip additional information.

‘1’ No debug information, but display warning and error messages. Furthermore, detailled information about syntax errors are displayed.

‘2’ All messages from ‘-d1’. Additionally, information about the current steps is displayed.

‘3’ All messages from ‘-d2’. Additionally, the structure of the process is shown, i.e. when a Petri net is generated...

‘4’ All messages from ‘-d3’. Additionally, a message is displayed each time a function is entered or left.

‘flex’ Displays messages from Flex. Can be combined with any other debug level.

‘bison’ Displays messages from Bison. Can be combined with any other debug level.

‘--reduce=0-5’

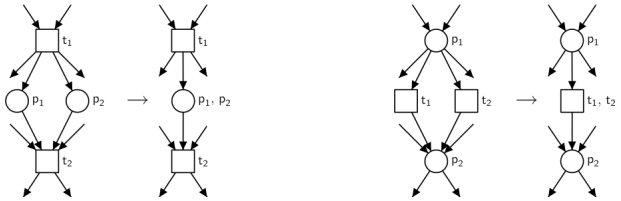
‘-r 0-5’ Apply several structural reduction rules to the generated Petri net model (implies mode ‘petrinet’ or ‘choreography’). The rules preserve deadlocks, livelocks and all deadlock-free communicating partners. The rules are organized in reduction levels:

‘0’ No rules are applied (standard).

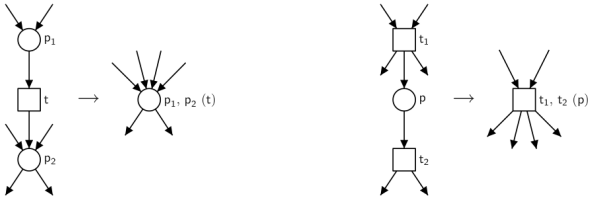
‘1’ Structural dead nodes are removed; that is, unmarked places with empty preset and transitions with a dead place in its preset are removed.

‘2’ All reduction rules from ‘-r1’. Additionally, unnecessary status places are removed. A status place is considered unnecessary if it has no outgoing arcs.

‘3’ All reduction rules from ‘-r2’. Additionally, identical nodes are merged. Two nodes are considered identical if their presets and postsets are equal:



‘4’ All reduction rules from ‘-r3’. Additionally, remove serial nodes:



‘5’ All reduction rules from ‘-r4’. Additionally, remove self-loop nodes.

3.1.1 Modes

When invoking BPEL2oWFN several modes are possible.

‘--mode=*modus*’

‘-m *modus*’

BPEL2oWFN supports different modes for handling input BPEL files: ‘*modus*’ can be one of the following:

‘ast’

Outputs the AST (abstract syntax tree) generated while parsing the input file to standard output. This option is mostly used for debug-

ging reasons since it shows the implicit transformations and the phylum names used when generating the Petri net.

'`cfg`'

For control flow analysis (a form of static analysis) a CFG (Control Flow Graph) is generated. It can be printed in graphical (dot) representation. With the CFG, several design flaws of BPEL processes such as cyclic control links or read access to uninitialized variables can be detected statically. Furthermore, faulty constellations such as conflicting receiving activities can be found using the '`cfg`' mode.

'`choreography`'

The '`choreography`' mode[1] is an extension of the '`petrinet`' mode. In the choreography mode, several BPEL processes can be parsed, and a Petri net model of their composition is generated.

For examples, check '`test/bpel4chor`' directory. When combined with LoLA file output, an additional '`.task`' file is generated. With the help of this file LoLA can check for weak termination of the composition.

Note that the choreography mode is only tested with the '`small`' mode. To support the translation of a BPEL4Chor choreography, a participant topology can be additionally parsed using the '`topology`' parameter.

'`petrinet`'

Generates a Petri net representing the semantics of the given process. Other options can be added to simplify or modify that generated Petri net (see below).

'`pretty`'

Outputs the parsed BPEL file in XML representation. This option is mostly used for debugging reasons as it shows the implicit transformations and the identifiers of the BPEL constructs.

At most one mode can be selected. If no mode is given, BPEL2oWFN acts like a plain BPEL parser; that is, the input file is read, but no output is generated.

3.1.2 Additional parameters

These options control some Petri net-related options.

'`--parameter=`*par*'
'`-p` *par*'

'`small`'

With the '`small`' parameter[2], only the communicational behavior of the input BPEL process is modeled. That is, the negative control flow (fault, termination, or compensation handlers, as well as `<exit>`, `<throw>`, `<compensate>`, `<compensateScope>` activities) is not translated to the Petri net model. When combined with '`reduce`', this parameter yields the most compact Petri net model.

'`fhfaults`'

Confines the '`standardfaults`' parameter: in the negative control flow (in activities in fault handlers), no further BPEL standard faults can occur.

[1] This mode was formally called '`consinstency`'.

[2] This mode was formally called '`communicationonly`'.

‘`nointerface`’
: When creating a ‘`.dot`’ file, no interface is printed.

‘`reduce`’
: Apply all implemented structural reduction rules. This parameter is a shortcut for ‘`-r5`’ and overrides any other defined reduction level.

‘`standardfaults`’
: Model the occurrence of standard faults. When this parameter is ommited, only user-defined faults, that is, faults thrown with `<throw>` activities, and join failures can occur. With the ‘`standardfaults`’ parameter, also the occurrence of other BPEL standard faults is modeled. This parameter yields the most-detailled, and thus biggest Petri net model.

‘`variables`’
: Add places for the variables of the input BPEL process to the Petri net model. As the generated model abstracts from data, that is, a low-level Petri net is generated, the ‘`variables`’ parameter also does not introduce data aspects. Thus, this mode is experimental.

If you want to enable more than one parameter you have to add ‘`-p`’/ ‘`--parameter`’ to each parameter.

3.1.3 Output formats

Especially for the Petri net mode, a variaty of output formats are supported. There are invoked by the following option:

‘`--format=`*`fileformat`*’
‘`-f` *`fileformat`*’
: Creates a file in a given ouput file format. Each file format is only available in certain modes. If you want to use more than one output file format you have to add ‘`-f`’/ ‘`--format`’ to each file format. Please note that the underlying modes of the given file formats are the same. You cannot, for example, create XML and LoLA files together since XML requires the mode ‘`pretty`’, whereas LoLA requires the mode ‘`petrinet`’.

  Petri net file formats (imply mode ‘`petrinet`’ or ‘`choreography`’):

  ‘`apnn`’ Outputs the inner of the generated open workflow net in APNN (Abstract Petri Net Notation). When the parameter ‘`-o`’ is used, a file with the suffix ‘`.apnn`’ is created.

  ‘`ina`’ Outputs the inner of the generated open workflow net as untimed low-level Petri net in INA (Integrated Net Analyzer) format. When the parameter ‘`-o`’ is used, a file with the suffix ‘`.pnt`’ is created.

  ‘`lola`’ Outputs the inner of the generated open workflow net as low-level Petri net in LoLA (Low-Level Analyzer) file format. When the parameter ‘`-o`’ is used, a file with the suffix ‘`.lola`’ is created.

  ‘`owfn`’ Outputs the generated open workflow net in Fiona file format. Note that the Fiona file format is — together with the PNML file format — the only Petri net output format that outputs the complete open workflow net, that is, also

the interface is exported. When the parameter '`-o`' is used, a file with the suffix '`.owfn`' is created.

'`pep`' Outputs the inner of the generated open workflow net as low-level Petri net in low-level PEP notation. When the parameter '`-o`' is used, a file with the suffix '`.llnet`' is created.

'`pnml`' Outputs the generated open workflow net in PNML (Petri Net Markup Language). Note that the PNML file format is — together with the Fiona file format — the only Petri net output format that outputs the complete open workflow net, that is, also the interface is exported. Currently, the interface places are annotated using a `<type>` tag which is only supported by Yasper[3]. When the parameter '`-o`' is used, a file with the suffix '`.pnml`' is created.

'`spin`' Outputs the inner of the generated open workflow net as low-level Petri net in Promela (Process Meta Language) for the model checker SPIN. When the parameter '`-o`' is used, a file with the suffix '`.spin`' is created.

Other file formats (note the required mode):

'`dot`' When mode '`petrinet`' is used, the generated open workflow net is printed in Graphviz dot representation. When mode '`ast`' is used, the AST (abstract syntax tree) is printed in Graphviz dot representation. When mode '`cfg`' is used, the CFG (control flow graph) is printed in Graphviz dot representation.

In any case, when the tool `dot` is found in the search path during configuration of BPEL2oWFN and the parameter '`-o`' is used, `dot` is used to generate a PNG (Portable Network Image) file. In this case, two files with the suffixes '`.dot`' and '`.png`' are created. Note that when the '`ast`' mode is used with the '`dot`' file format, the '`-o`' parameter has to be used.

'`info`' When mode '`petrinet`' is used, information about the places and transitions of the generated net in a proprietary ASCII-based format. For each place and transition, all roles, that is, inscriptions of the Petri net patterns, are listed. The information can be used to correlate the generated Petri net model with the input BPEL process. When the parameter '`-o`' is used, a file with the suffix '`.info`' is created.

'`xml`' When the mode '`pretty`' is used, the pretty-printed input BPEL process — with the implicit transformation rules applied – exported in XML (Extensible Markup Lanuage). When the parameter '`-o`' is used, a file with the suffix '`.xml`' is created.

3.2 Exit Values

0 No error occurred.

[3] Yasper is available at `http://www.yasper.org`.

1 A critical error occured; that is, a fault was detected that makes further processing impossible.

2 An input file could not be opened.

3 A syntax error in the input BPEL occurred. The input file cannot be further processed.

4 Any other error.

3.3 Examples

In this section we show some examples how BPEL2oWFN can be invoked. See Chapter 5 [File Formats], page 22 for more examples.

'`bpel2owfn -i sample.bpel -m petrinet -f lola -f info -o -p reduce`'
Reads the file '`sample.bpel`', generates a structural reduced low-level Petri net and saves it in a LoLA file '`sample.lola`'. For further information a file '`sample.info`' is generated.

'`bpel2owfn -i sample.bpel -mpetrinet -fowfn -d3 -o`'
Reads the file '`sample.bpel`', generates a low-level open workflow net and saves it in an oWFN file '`sample.owfn`'. For further information a file '`sample.info`' is generated. During the conversion several debug messages are printed to standard output.

'*prog* `| bpel2owfn -fdot -m petrinet | dot -Tps -osample.ps`'
Runs the program *prog* and reads its output as BPEL process, generates a Petri net and outputs its Graphviz dot representation. This stream is read by `dot` which layouts the Petri net and creates an output PostScript file '`sample.ps`'.

'`bpel2owfn -i sample.bpel -m ast`'
Reads the file '`sample.bpel`' and prints the abstract syntax tree (AST) to standard output.

'`bpel2owfn -m choreography -i service1.bpel -i service2.bpel -f lola -o`'
Reads the files '`service1.bpel`' and '`service2.bpel`' and creates a Petri net model of their composition. The result is written to the LoLA file '`service1_service2.lola`'. Furthermore, an analysis file '`service1_service2.task`' is written that can be processed by LoLA.

Further examples for invocations of BPEL2oWFN can be found in the '`tests`' directory of the source distribution.

4 Warnings and Error Messages

BPEL2oWFN performs several analysis steps on the input BPEL process. These messages are displayed during parsing and postprocessing of the process, and can be classified as follows:

- **Notices** do not report errors, but just give information about the translation process.
- **Syntax error messages** report problems during the lexical or syntactical analysis of the process. See Chapter 6 [FAQ and Known Bugs], page 26 for information about handling syntax errors.
- **Static analysis messages** occur when a test described in the WS-BPEL specification detects an error in the process. When such an error is found, a WS-BPEL processor must reject the process. If the process is an abstract process, the static analysis errors can be considered as warnings as abstract processes are not meant to be executed.
- **Warnings** report potential problems in the input process. The warned problem should be corrected to assure executability of the input process.
- **Errors** report problems that are explicitly mentioned in the WS-BPEL specification. They should be corrected to avoid runtime errors. Furthermore, problems can arise during the generation of a Petri net model.
- **Critical errors** make a further processing of the input process impossible and terminate GNU BPEL2oWFN immediately.

An example for a message is this:

```
CubeManagement.bpel:566 - [W00114]
variable 'waitResponse' used as 'variable' in <from> might be uninitialized
```

The first line contains the filename of the input process '`CubeManagement.bpel`' and the line number '`566`' of the displayed issue. The line number might be imprecise; that is, it might deviate up or down a few lines. After the line number, the error code is displayed. '`W00114`' stands for a warning with code 114. The detailed description of the messages can be suppressed with option '`-d0`'.

Further details can be taken from the table below.

Code	Type	Description
2	static analysis	A WS-BPEL processor MUST reject any WSDL portType definition that includes overloaded operation names.[1]
3	static analysis	If the value of `exitOnStandardFault` of a `<scope>` or `<process>` is set to `"yes"`, then a fault handler that explicitly targets the WS-BPEL standard faults MUST NOT be used in that scope.
6	static analysis	The `<rethrow>` activity MUST only be used within a faultHandler (i.e. `<catch>` and `<catchAll>` elements).
5	static analysis	If the `portType` attribute is included for readability, in a `<receive>`, `<reply>`, `<invoke>`, `<onEvent>` or `<onMessage>` element, the value of the `portType` attribute MUST match the `portType` value implied by the combination of the specified `partnerLink` and the role implicitly specified by the activity.

[1] The descriptions for static analysis messages are taken from Appendix B of the WS-BPEL specification.

7	static analysis	The `<compensateScope>` activity MUST only be used from within a `faultHandler`, another `compensationHandler`, or a `terminationHandler`.
8	static analysis	The `<compensate>` activity MUST only be used from within a `faultHandler`, another `compensationHandler`, or a `terminationHandler`.
15	static analysis	To be instantiated, an executable business process MUST contain at least one `<receive>` or `<pick>` activity annotated with a `createInstance="yes"` attribute.
16	static analysis	A `partnerLink` MUST specify the `myRole` or the `partnerRole`, or both.
17	static analysis	The `initializePartnerRole` attribute MUST NOT be used on a partnerLink that does not have a partner role.
18	static analysis	The name of a `partnerLink` MUST be unique among the names of all partnerLinks defined within the same immediately enclosing scope.
23	static analysis	The name of a variable MUST be unique among the names of all variables defined within the same immediately enclosing scope.
24	static analysis	Variable names are `BPELVariableNames`, that is, NCNames (as defined in XML Schema specification) but in addition they MUST NOT contain the '`.`' character.
25	static analysis	The `messageType`, type or `element` attributes are used to specify the type of a variable. Exactly one of these attributes MUST be used.
32	static analysis	For `<assign>`, the `<from>` and `<to>` element MUST be one of the specified variants.[2]
35	static analysis	In the from-spec of the partnerLink variant of `<assign>` the value `"myRole"` for attribute `endpointReference` is only permitted when the partnerLink specifies the attribute `myRole`.
36	static analysis	In the from-spec of the partnerLink variant of `<assign>` the value `"partnerRole"` for attribute `endpointReference` is only permitted when the partnerLink specifies the attribute `partnerRole`.
37	static analysis	In the to-spec of the partnerLink variant of `<assign>` only partnerLinks are permitted which specify the attribute `partnerRole`.
44	static analysis	The name of a `<correlationSet>` MUST be unique among the names of all `<correlationSet>` defined within the same immediately enclosing scope.

[2] The specification describes all allowed combinations of elements and attributes in from- and to-specifications.

51	static analysis	The `inputVariable` attribute MUST NOT be used on an `Invoke` activity that contains `<toPart>` elements.
52	static analysis	The `outputVariable` attribute MUST NOT be used on an `Invoke` activity that contains `<toPart>` elements.
55	static analysis	For `<receive>`, if `<fromPart>` elements are used on a `<receive>` activity then the variable attribute MUST NOT be used on the same activity.
56	static analysis	A "start activity" is a `<receive>` or `<pick>` activity that is annotated with a `createInstance="yes"` attribute. Activities other than the following: start activities, `<scope>`, `<flow>` and `<sequence>` MUST NOT be performed prior to or simultaneously with start activities.
57	static analysis	If a process has multiple start activities with correlation sets then all such activities MUST share at least one common correlationSet and all common correlationSets defined on all the activities MUST have the value of the `initiate` attribute be set to `"join"`.
59	static analysis	For `<reply>`, if `<toPart>` elements are used on a `<reply>` activity then the `variable` attribute MUST NOT be used on the same activity.
62	static analysis	If `<pick>` has a `createInstance` attribute with a value of '`yes`', the events in the `<pick>` MUST all be `<onMessage>` events.
63	static analysis	The semantics of the `<onMessage>` event are identical to a `<receive>` activity regarding the optional nature of the `variable` attribute or `<fromPart>` elements, if `<fromPart>` elements on an activity then the variable attribute MUST NOT be used on the same activity (see SA00055).
64	static analysis	For `<flow>`, a declared link's name MUST be unique among all `<link>` names defined within the same immediately enclosing `<flow>`.
65	static analysis	The value of the `linkName` attribute of `<source>` or `<target>` MUST be the name of a `<link>` declared in an enclosing `<flow>` activity.
66	static analysis	Every link declared within a `<flow>` activity MUST have exactly one activity within the `<flow>` as its source and exactly one activity within the `<flow>` as its target.
67	static analysis	Two different links MUST NOT share the same source and target activities; that is, at most one link may be used to connect two activities.
68	static analysis	An activity MAY declare itself to be the source of one or more links by including one or more `<source>` elements. Each `<source>` element MUST use a distinct link name.

69	static analysis	An activity MAY declare itself to be the target of one or more links by including one or more `<target>` elements. Each `<target>` element associated with a given activity MUST use a link name distinct from all other `<target>` elements at that activity.
70	static analysis	A link MUST NOT cross the boundary of a repeatable construct or the `<compensationHandler>` element. This means, a link used within a repeatable construct (`<while>`, `<repeatUntil>`, `<forEach>`, `<eventHandlers>`) or a `<compensationHandler>` MUST be declared in a `<flow>` that is itself nested inside the repeatable construct or `<compensationHandler>`.
71	static analysis	A link that crosses a `<catch>`, `<catchAll>` or `<terminationHandler>` element boundary MUST be outbound only, that is, it MUST have its source activity within the `<faultHandlers>` or `<terminationHandler>`, and its target activity outside of the scope associated with the handler.
72	static analysis	A `<link>` declared in a `<flow>` MUST NOT create a control cycle, that is, the source activity must not have the target activity as a logically preceding activity.[3]
73	static analysis	The expression for a join condition MUST be constructed using only Boolean operators and the activity's incoming links' status values.
74	static analysis	The expressions in `<startCounterValue>` and `<finalCounterValue>` MUST return a TII (meaning they contain at least one character) that can be validated as a `xsd:unsignedInt`. Static analysis MAY be used to detect this erroneous situation at design time when possible (for example, when the expression is a constant).
75	static analysis	For the `<forEach>` activity, `<branches>` is an integer value expression. Static analysis MAY be used to detect if the integer value is larger than the number of directly enclosed activities of `<forEach>` at design time when possible (for example, when the branches expression is a constant).
76	static analysis	For `<forEach>` the enclosed scope MUST NOT declare a variable with the same name as specified in the `counterName` attribute of `<forEach>`.
77	static analysis	The value of the `target` attribute on a `<compensateScope>` activity MUST refer to the name of an immediately enclosed `scope` of the `scope` containing the FCT-handler with the `<compensateScope>` activity. This includes immediately enclosed scopes of an event handler (`<onEvent>` or `<onAlarm>`) associated with the same `scope`.
78	static analysis	The `target` attribute of a `<compensateScope>` activity MUST refer to a `scope` or an `invoke` activity with a fault handler or compensation handler.

[3] This fault can only be detected in mode mode '`cfg`'.

79	static analysis	The root `scope` inside a FCT-handler MUST not have a compensation handler.
80	static analysis	There MUST be at least one `<catch>` or `<catchAll>` element within a `<faultHandlers>` element.
81	static analysis	For the `<catch>` construct; to have a defined type associated with the fault variable, the `faultVariable` attribute MUST only be used if either the `faultMessageType` or `faultElement` attributes, but not both, accompany it. The `faultMessageType` and `faultElement` attributes MUST NOT be used unless accompanied by `faultVariable` attribute.
82	static analysis	The peer-scope dependency relation MUST NOT include cycles. In other words, WS-BPEL forbids a process in which there are peer scopes S1 and S2 such that S1 has a peer-scope dependency on S2 and S2 has a peer-scope dependency on S1.[4]
83	static analysis	An event handler MUST contain at least one `<onEvent>` or `<onAlarm>` element.
84	static analysis	The `partnerLink` reference of `<onEvent>` MUST resolve to a partner link declared in the process in the following order: the associated scope first and then the ancestor scopes.
88	static analysis	For `<onEvent>`, the resolution order of the `correlation set`(s) referenced by `<correlation>` MUST be first the associated scope and then the ancestor scopes.
91	static analysis	A scope with the `isolated` attribute set to `"yes"` is called an isolated scope. Isolated scopes MUST NOT contain other isolated scopes.
92	static analysis	Within a scope, the name of all named immediately enclosed scopes MUST be unique.
93	static analysis	Identical `<catch>` constructs MUST NOT exist within a `<faultHandlers>` element.
100	notice	Either a non-standard element[5] was parsed or a BPEL activity was considered as misplaced. In the first case, a non-standard element was parsed when the parser expected a BPEL standard activity. Then, a syntax error is printed and the whole element is ignored. The parse error and this message can usually be ignored, as non-standard elements would neither we translated to a Petri net model nor are constrained by the WS-BPEL specification. In the second case, a syntactically correct BPEL was skipped, because it was misplaced. As an example, consider two activities embedded in a `<while>` activity without an enclosing `<sequence>` activity. In this case, the second activity triggers this message.

[4] This fault can only be detected in mode mode '`cfg`'.

[5] All elements that are not explicitly defined in the WS-BPEL specification (e.g., elements from other namespaces) are considered as "non-standard".

101	notice	The `<partners>` construct (only supported by BPEL4WS 1.1) is skipped due to a syntax error.
102	notice	The `<to>` or `<from>` construct is skipped due to a syntax error.
103	notice	The `<condition>` construct is skipped due to a syntax error.
104	critical	When a syntax error occurs, BPEL2oWFN tries to recover and continues parsing the input file after skipping the faulty or unknown element. Sometimes, however, the skipping of activities yields to situations where a further analysis of the BPEL process is impossible. In this case, the syntax of the process has to be fixed or non-standard elements have to be removed or out-commented.
105	notice	When a syntax error occurs, BPEL2oWFN tries to recover and continues parsing the input file after skipping the faulty or unknown element. If it is possible to continue, the analysis results might be faulty. In this case, the syntax of the process has to be fixed or non-standard elements have to be removed or out-commented.
106	warning	CFG analysis detected two receiving activities (i.e., `<receive>`, `<onEvent>`, `<onMessage>`, synchronous `<invoke>`) that might be activated concurrently and share the same partner link, port type, operation, and correlation set. When a message is sent to the process, these activities are in *conflict*; that is, it is not defined which activity will receive an inbound message. At runtime, the standard fault '`bpel:conflictingReceive`' would be thrown.[6]
107	warning	A mandatory attribute of an activity was not defined. Especially for communicating activities, the absence of `partnerLink` and `operation` might hamper the subsequent analysis and Petri net generation.
108	syntax	An attribute was set to a value that violates the attribute's given type. Only the types `tBoolean`, `tInitiate`, `tRoles`, and `tPattern` are checked.
109	warning	A variable referenced in an activity was not defined before; that is, no matching `<variable>` definition was found in a parent scope.
110	warning	A partner link referenced in an activity was not defined before; that is, no matching `<partnerLink>` definition was found in the process.
111	warning	A correlation set referenced in an activity was not defined before; that is, no matching `<correlationSet>` definition was found in a parent scope.
112	notice	The `<literal>` construct is skipped due to a syntax error.

[6] This fault can only be detected in mode mode '`cfg`'.

113	syntax	A UTF-8 character was read in the input file. As BPEL2oWFN's scanner does not support Unicode, all UTF-8 characters are ignored. This message is only displayed when the first UTF-8 character is read.
114	warning	CFG analysis detected a read access to a variable that was not initialized before. At runtime, the standard fault '`bpel:uninitializedVariable`' would be thrown.[7]
115	notice	The process definition defines an abstract process profile, and thus allows several "opaque" constructs. When processing and analyzing an abstract process, BPEL2oWFN might report error messages that where designed for executable processes, for example missing attributes. Static analysis errors detected in an abstract process are reported as warnings.
116	notice	An `<opaqueActivity>` of an abstract process is modeled by an `<empty>` activity.
117	notice	When using the parameter '`small`', the occurrence of join failures is not modeled. Thus, any activity is treated as if the attribute '`suppressJoinFailure`' is set to '`yes`'.[8]
118	notice	A user-defined transition condition is ignored and modeled as "n-out-of-n" ('`true`') instead.
119	notice	A user-defined transition condition is ignored and modeled as "1-out-of-n" (XOR) instead.
120	notice	When using the parameter '`small`', the FTC (fault, termination, and compensation) handlers are not modeled.
121	notice	When using the parameter '`small`', activities of the negative control flow (`<exit>`, `<throw>`, `<compensate>`, and `<compensateScope>`) are replaced by an `<empty>` activity.
122	notice	A syntax error in the BPEL4Chor chorography file occurred.
123	notice	A syntax error in the WSDL input file occurred.
124	notice	An XML Schema element nested in a WSDL <types> element was ignored. This is usually no problem, as WSDL `<types>` are not evaluated in subsequent analysis or translation.
125	notice	A variable property element was ignored while parsing the input WSDL file.
126	warning	A WSDL `<message>` referenced in a WSDL `<operation>` was not found.
127	warning	A WSDL `<portType>` referenced in a WSDL `<role>` was not found.

[7] This fault can only be detected in mode mode '`cfg`'.

[8] If the attribute '`suppressJoinFailure`' is not explicitly defined for an activity, the value is inherited by the parent activity.

128	warning	A WSDL `<operation>` referenced in a BPEL activity was not specified in the input WSDL file.
129	warning	A WSDL `<role>` of a `partnerLinkType` referenced by a `<partnerLink>` was not defined in the specified `<partnerLinkType>` in the input WSDL file.
130	warning	A WSDL `<partnerLinkType>` referenced by a `<partnerLink>` was not specified in the input WSDL file.
131	error	An activity has neither a `name` or `id` attribute and thus can not be linked with a BPEL4Chor `<messageLink>`.
132	error	An activity has neither could not be linked with a BPEL4Chor `<messageLink>` using the activity's `name` or `id` attribute.
133	notice	An `<extensionActivity>` is replaced by an `<opaqueActivity>` (cf. notice 116).
134	warning	A BPEL4Chor `<participantType>` was defined twice.
135	warning	The `<participantType>` referenced by a BPEL4Chor `<participant>` was not found.
136	error	The value of a `<forEach>`'s attribute `id` or `name` does not reference a BPEL4Chor `<participant>` or `<participantSet>`. Thus, the `<forEach>` activity is not grounded to the BPEL4Chor topology.
137	error	In a BPEL4Chor topology, no XML namespace was defined for a `<participant>`. In a WS-BPEL file, the attribute `targetNamespace` could not to be grounded to a BPEL4Chor `<participant>`.
138	notice	In a BPEL4Chor topology, a partner link specified for an activity was not found. Instead, the name of the specified id is used as a partner link.

5 File Formats

In this chapter, we show how a BPEL process can be translated to a Petri net model an then exported to several output file formats. Consider the following simple BPEL process '`example.bpel`':

```
<process name="exampleprocess" targetNamespace="www.gnu.org/software/bpel2owfn">
  <partnerLinks>
    <partnerLink name="PL" partnerLinkType="PLT"
      myrole="exampleprocess" partnerRole="exampleuser" />
  </partnerLinks>

  <sequence>
    <receive partnerLink="PL" operation="req" createInstance="yes" />
    <reply partnerLink="PL" operation="ack" />
  </sequence>
</process>
```

This process just waits for a message '`req`' on partner link '`PL`' and replies to this message with '`ack`' on the same partner link. To parse this BPEL process, BPEL2oWFN has to be invoked with

```
bpel2owfn -i example.bpel
```

which responds with the output:

```
================================================================================
GNU BPEL2oWFN 2.0.1 reading from file 'example.bpel'
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
3 activities (2 basic, 1 structured, 0 scopes) + 3 implicit activities
0 handlers (0 FH, 0 TH, 0 CH, 0 EH) + 1 implicit handlers
0 links, 0 variables

[SYNTAX ANALYSIS] No syntax errors found.
[STATIC ANALYSIS] No errors found checking 44 statics analysis requirements.
[OTHER ANALYSIS]  No other errors found.
--------------------------------------------------------------------------------
```

This means, the process consists of three activities (two basic activities and one structured activities), no handlers, no links and no variables. On the bottom the analysis results are summarized: no syntactic, static, or other error was found.

Furthermore, three "implicit" activities are counted: The WS-BPEL specification describes several implicit transformations of the input process, as well as standard fault, termination and compensation handlers. In the considered BPEL process, no fault handlers are specified. Thus, a standard fault handler is added by BPEL2oWFN:

```
<faultHandlers>
  <catchAll>
    <sequence>
      <compensate />
      <rethrow />
    </sequence>
  </catchAll>
</faultHandlers>
```

To see how the BPEL process looks like after applying the transformation rules and adding the standard handlers, BPEL2oWFN output the manipulated process using its pretty-printer:

```
bpel2owfn -i example.bpel -m pretty
```

The manipulated process looks like this:

```
<process id="1" abstractProcess="no" exitOnStandardFault="no" name="exampleprocess"
 suppressJoinFailure="no" targetNamespace="www.gnu.org/software/bpel2owfn">
  <partnerLinks>
    <partnerLink id="3" myrole="exampleprocess"
       name="PL" partnerLinkType="PLT" partnerRole="exampleuser" />
  </partnerLinks>
  <faultHandlers id="4">
    <catchAll id="13">
      <sequence id="12" suppressJoinFailure="no">
        <compensate id="11" suppressJoinFailure="no">
        </compensate>
        <rethrow id="10">
        </rethrow>
      </sequence>
    </catchAll>
  </faultHandlers>
  <sequence id="7" suppressJoinFailure="no">
    <receive id="8" createInstance="yes" operation="req"
       partnerLink="PL" suppressJoinFailure="no">
    </receive>
    <reply id="9" operation="ack" partnerLink="PL" suppressJoinFailure="no">
    </reply>
  </sequence>
</process>
```

Each activity is printed together with its attributes. Note that the standard values of several attributes (e.g., '`abstractProcess`' or '`suppressJoinFailure`') are added. Furthermore, an identifier (attribute '`id`') was added to every activity.

We now want to create a compact Petri net model of the BPEL process, using the '`petrinet`' mode and the '`small`' parameter:

```
bpel2owfn -i example.bpel -m petrinet -p small
```

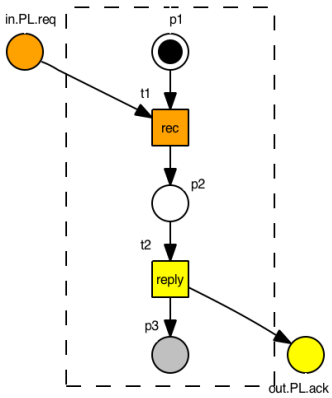
BPEL2oWFN now also displays statistics of the generated Petri net model:

```
|P|=5, |P_in|= 1, |P_out|= 1, |T|=2, |F|=6
```

The generated Petri net model consists of five places, including one input and one output place, two transitions and six arcs. To create a graphical representation, invoke BPEL2oWFN with the following options:

```
bpel2owfn -i example.bpel -m petrinet -p small -f dot -o
```

This command creates a file '`example.dot`', containing a Graphviz dot representation of the Petri net, and—if the `dot` tool was found in the search path—a PNG (Portable Network Graphics) an image file '`example.png`'. The latter looks like this:



Petri net generated from example.bpel

The graphic depicts the generated open workflow net. The inner of the net, that is, all nodes except the interface places, are depicted inside the dashed box, whereas the interface is depicted outside the frame. Input places and all connected transitions are colored orange. Similarly, output places and connected transitions are colored yellow. Gray places belong to the final marking, that is, the marking [**p3**] is the final marking of the oWFN.

To reach this final marking, the environment has to send a message **in.PL.req**, followed by receiving a message **out.PL.ack**. The name of the communication places is composed by the communication direction ("in" or "out"), the partner link's name ('`PL`') and the operations name ('`req`' or '`ack`').

For this very small process, it is easy to validate the generated Petri net model, that is, to compare the intended semantics by the actually modeled semantics. Especially the correlation between the nodes of the Petri net and the activities of the input BPEL process is not obvious for larger processes. To this end,

```
bpel2owfn -i example.bpel -m petrinet -p small -f info
```

displays an information file, consisting of all the Petri net nodes' roles.

```
PLACES:
ID      TYPE            ROLES
p1      internal        1.internal.initial
                        7.initial
                        7.internal.initial
                        8.initial
                        8.internal.initial
p2      internal        8.final
                        8.internal.final
                        9.initial
                        9.internal.initial
p3      internal        1.internal.final
                        7.final
                        7.internal.final
                        9.final
                        9.internal.final
in.PL.req       input           in.PL.req
out.PL.ack      output          out.PL.ack

TRANSITIONS:
ID      ROLES
t1      8.internal.receive
t2      9.internal.reply
```

This file has to be read as follows: the place '`p1`' has the type internal (i.e., is not connected with an interface place) and has the roles '`1.internal.initial`', '`7.initial`',

‘7.internal.initial’, ‘8.initial’, and ‘8.internal.initial’. While the prefix of each role is the identifier of an activity (‘1’ for the <process>, ‘7’ for the <sequence>, and ‘8’ for the <receive>), the suffix specifies the role inside the respective pattern. Without going too much into details, ‘1.internal.initial’ is the role of the initial place of the pattern for the <process>, whereas, for example ‘7.internal.final’ is the final place of the <sequence>’s pattern. Similarly, roles of transitions are specified. Multiple roles of a single place arise due to the merging of distinct places during the composition of the several patterns.

Now that we have convinced ourselves that the generated net reflects the intended behavior of the BPEL process, we can export the Petri net model to an output file to process it by analysis tools. In this case, we want to create a Fiona open workflow net executing

```
bpel2owfn -i example.bpel -m petrinet -p small -f owfn -o
```

which creates a file ‘example.owfn’:

```
{
  generated by: BPEL2oWFN 2.0.1
  input file:   ‘example.bpel’ (process ‘exampleprocess’)
  invocation:   ‘bpel2owfn -i example.bpel -m petrinet -p small -f owfn’
  net size:     |P|=5, |P_in|= 1, |P_out|= 1, |T|=2, |F|=6
}

PLACE
  INTERNAL
    p1, p2, p3;

  INPUT
    in.PL.req {$ MAX_OCCURRENCES = 1 $};

  OUTPUT
    out.PL.ack {$ MAX_OCCURRENCES = 1 $};


INITIALMARKING
  p1:    1 {initial place};

FINALMARKING
  p3 {final place};


TRANSITION t1 { input }
  CONSUME in.PL.req, p1;
  PRODUCE p2;

TRANSITION t2 { output }
  CONSUME p2;
  PRODUCE out.PL.ack, p3;


{ END OF FILE ‘example.owfn’ }
```

This is finally the oWFN model of the BPEL process that can be analyzed by Fiona[1].

[1] Fiona is available at http://www.informatik.hu-berlin.de/top/tools4bpel.

6 FAQ and Known Bugs

6.1 Frequently Asked Questions

- **Why does the parser reject my BPEL file?**

  BPEL2oWFN uses Flex and Bison to implement the parser. We decided do not use an off-the-shelf XML parser generator as we did not found a suitable platform-independent parser generator whose license was "compatible" to the GNU GPL (General Public License). Furthermore, we use the term generator Kimwitu++ to describe and process the AST (abstract syntax tree), and the trio Flex/Bison/Kimwitu++ integrates seamlessly. Though the grammar has to be defined manually, the generated parser is very flexible as it allows to process BPEL4WS 1.1, WS-BPEL 2.0, and to some extend BPEL4WS 1.0 processes.

  However, the parser does not support XML namespaces. BPEL2oWFN will ignore namespace prefixes and skip all elements that are not explicitly covered by the WS-BPEL 2.0, BPEL4WS 1.2 or WSDL 1.1 specification, respectively. Nevertheless, skipping elements are reported as syntax error message (cf. warning message [W00104]).

  As a solution, try removing or commenting non-standard elements.

- **I validated my process using an XML validator. Why does BPEL2oWFN still reports syntax errors?**

  Well, because there *are* such errors. Many BPEL editors generate invalid BPEL. Even the official WS-BPEL 2.0 specification contains processes with syntax errors. Furthermore, a lot of syntax errors cannot be covered with XSD (XML Schema Definition) validation. Even if the considered process run on existing engines, BPEL2oWFN might reject it, as it stubbornly follows the WS-BPEL specification.

- **Why LoLA does not accept the generated files and reports parse errors in the first line?**

  This problem occurs using a pre-compiled windows version of BPEL2oWFN. The generated files are in Windows format, yet LoLA only supports files in Unix format. To overcome this limitation of LoLA, use a tool like '`dos2unix`' or change the file format in an editor like '`vi`'.

6.2 Known Bugs

Though this is the second major release version of BPEL2oWFN, it might still contain poorly tested, inefficient code.

- **Problem:** BPEL2oWFN crashes during the translation of an abstract BPEL process.

  Diagnosis: The implemented semantics of was mainly created to support executable BPEL processes. Therefore, the translation of abstract BPEL processes (formerly called *business protocols*) might be buggy. In particular, the allowed absence of implementation details hampers the analysis of the process and the generation of a formal model.

  Solution: To avoid errors, at least each communicating activity should be defined with `partnerLink` and `operation` attribute, and `<invoke>` activities should be defined with `inputVariable` and/or `outputVariable` to distinguish the respective asynchronous and synchronous occurrence.

6.3 Reporting Bugs

If you find a bug in BPEL2oWFN or have a question, please first check that it is not a known bug or a frequently asked question listed in above. Otherwise, please send us an email to `bug-bpel2owfn@gnu.org`. Include the version number which you can find by running '`bpel2owfn --version`'. Also include in your message the input BPEL process and the output that the program produced. We will try to answer your mail within a week.

If you have other questions, comments or suggestions about BPEL2oWFN, contact us via electronic mail to nlohmann@informatik.hu-berlin.de.

6.4 Contact Person

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6.5 Help BPEL2oWFN

BPEL2oWFN is now developed for one and a half year, and grown to a quite big program. Since November 2006, BPEL2oWFN is a GNU package, and the development is organized at Savannah (https://savannah.gnu.org/projects/bpel2owfn). We are always looking for developers and testers that can help us improving BPEL2oWFN.

7 Version History

After over year with minor changes and halfhearted bug fixes which were never released, BPEL2oWFN is now developed under the "Release Early, Release Often" maxime (see http://catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/ar01s04.html): Whenever enough integrated or a non-trivial changes have summed up, a new version is published. Though this releases might now always mark significant changes, they at least allow to quickly fix bugs and avoid infinite procrastination.

Version 2.4 (24 January 2010)

- This is a maintenance release that addresses a number of issues of the last 30 months.
- fixed bug #1387 (https://gna.org/bugs/?13837): assertion failed if choreographies are used without '`communicationonly`' parameter
- updated maintainer scripts
- implemented new final conditions for oWFN output (not '`ALL_EXTERNAL_PLACES_EMPTY`' any more)
- fixed oWFN output (problems with nested `ALL_OTHER_PLACES_EMPTY`)
- fixed bug #12110 (https://gna.org/bugs/?12110): compilation errors using GCC 4.3.1
- adapted the cleaning scripts
- renamed Makefile target '`hu-prepare`' to '`cvs-clean`'
- added '`--bug`' parameter
- neither Automake nor Autoconf set any gcc parameters
- removed '`extension-data.*`', because nobody will be working on this
- added Makefiles for a Manpage created by help2man
- fixed a small bug that yielded parse problems when strings appeared in `<documentation>` elements
- renamed generated configuration header to '`config.h`' to achieve compatibility with getopt and the sources generated by GNU gengetopt
- replaced previously patched files '`getopt.c`', '`getopt.h`', and '`getopt1.c`' by standard files from GNUlib
- changed versioning scheme from '`x.y.z`' to '`x.y`'
- completed task #6117 (https://gna.org/task/?6117): now using gengetopt to organize command line options
- completed task #6078 (https://gna.org/task/?6078): implement Woflan file format
- fixed bug #12126 (https://gna.org/bugs/?12126): `make distcheck` does not finish successfully
- added Makefile targets '`patch`' and '`patched`' to create and apply patches against the Gna! subversion repository (https://gna.org/svn/?group=service-tech)
- added a parameter '`decomp`' and implemented rudimentary decomposition support
- removed unnecessary files '`getopt.h`', '`getopt.c`', and '`getopt1.c`' from '`src`' directory
- overworked the test cases
- added code coverage checks using LTP LCOV (http://ltp.sourceforge.net/coverage/lcov.php); checks can be invoked in directory '`tests`' with `make prepare-cover cover`
- when static analysis checks [SA00007], [SA00077], or [SA00078] fail, the `error()` function is called instead of letting BPEL2oWFN run towards a possible segmentation fault

- completed task #6133 (http://gna.org/task/?6133): print number of partner links after parsing
- fixed a bug that occurred when BPEL2oWFN read a file from standard input
- cleaned Makefiles (removed explicit rules that were covered by implicit rules)
- removed maintainer scripts for Fink and RPM
- added configure scripts from Rachel and Fiona to set the necessary compilation flags to compile a Mac Universal binary ('`--enable-universal`'), a 64 bit binary ('`--enable-64bit`'), or a Windows MinGW binary ('`--enable-win32`')
- used option '`gnits`' for Automake, see http://www.gnu.org/software/automake/manual/automake.html
- moved acknowledgements from file '`AUTHOR`' to file '`THANKS`' to meet the strict Gnits requirements
- fixed a bug: Woflan TPN files were not created because of missing invokation in `main()` method
- overworked test scripts: creation of output files is checked now
- removed PNML and oWFN parser – this belongs into the Petri Net API
- changed license to GNU Affero General Public License Version 3
- corrected output of final condition (removed '`ALL_EXTERNAL_PLACES EMPTY`')

Version 2.0.3 (29 June 2007)

- miscellaneous:
  - adopted the GNU GPL Version 3
  - minor changes and bug fixes

Version 2.0.2 (15 June 2007)

- new features:
  - BPEL4Chor choreographies can be translated (further information to come)
  - WSDL files can be parsed to support the translation of a BPEL process
  - abstract BPEL processes (both BPEL4WS 1.1 and WS-BPEL 2.0) are now parsed
- miscellaneous:
  - when parsing multiple BPEL processes, wildcard like '`*.bpel`' can be used

Version 2.0.1 (11 May 2007)

- fixed bugs:
  - `<if>`/`<switch>` pattern did not work with parameter '`communicationonly`'
  - `<flow>` activities in repeated constructs (`<while>`, `<repeatUntil>`, ...) could result in unbounded nets
  - parameter '`xor`' could crash
- miscellaneous:
  - new parameter '`nointerface`' allows to create dot output of the generated Petri net model without drawing the interface
  - transitions of the Petri net model are labeled and colored according to their role (only for dot mode)
  - Petri net reduction rules can be chosen using the '`reduce`' option
  - improved performance of composition of nets in the '`consistency`' mode

Version 2.0.0 (20 April 2007)

- input:
  - executable BPEL4WS 1.1 processes
  - executable WS-BPEL 2.0 processes
  - abstract BPEL4WS 1.1 processes (experimental)
  - abstract WS-BPEL 2.0 processes (experimental)
- output:
  - Petri net file formats: APNN, INA (untimed, low-level), LoLA (low-level), Fiona oWFN, PEP notation (low-level), PNML (with extension to model interfaces), SPIN (Promela)
  - other file formats: Graphviz dot, XML
- implemented patterns:
  - overworked feature-complete Petri net semantics for BPEL4WS 1.1 and WS-BPEL 2.0
  - overworked simplified Petri net semantics to model the communicational behavior only
  - several versions of each pattern controlled by command-line parameters
- static analysis
  - 44 of 94 static analysis goals of the WS-BPEL specification are checked
  - read access to uninitialized variables can be detected using the CFG (control flow graph)
  - conflicting receiving activities can be detected using the CFG
- miscellaneous:
  - completely overworked architecture
  - all Petri net-related functions are packaged to a Petri net API (application programming interface) to be published independently of BPEL2oWFN soon
  - statistics of the input process are displayed after implicit transformation rules are applied
  - messages are classified (error, warning, etc.) and numbered to allow for a detailed description in the manual

Version 1.2 (6 April 2006)

- overworked patterns:
  - more parameterized versions of the Stahl-semantics (see version 1.1):
    - acyclic models (also acyclic event handlers)
    - models without variables
    - models without standard faults occuring while handling a fault

    For more information please refer to the User's Manual.
- static analysis:
  - A control flow graph can be built and used to detect the use of uninitialized variables.
- miscellaneous:
  - The command-line parameter '`-p finishloop`' is renamed to '`-p finalloop`'.
  - Structural reduction rules remove all structural dead nodes of the generated Petri net model.
- fixed bugs:
  - Pattern of asynchronous `<invoke>` activity does no longer receive messages.
  - Structural reduction rules no longer change the semantics of the `<switch>` activity.
  - Structural reduction rules no longer remove the loop transition for deadlock search.

Version 1.1 (24 February 2006)

- new output formats:
  - APNN (Abstract Petri Net Notation) Petri net
  - PNML (Petri Net Markup Language) Petri net
  - low-level PEP (Programming Environment based on Petri Nets) Petri net
- overworked patterns:
  - the Stahl-semantics (see version 1.0) has been enhanced and can be parametrized:
    - original semantics
    - models without BPEL's standard faults
    - acyclic models

    For more information please refer to the User's Manual.
- static analysis:
  - To reduce the size of the Petri net model static analysis is used to only generate nodes for the DPE (dead path elimination) when necessary.
- miscellaneous:
  - The compiler generator tools Flex, Bison and Kimwitu++ are not any more necessary to compile BPEL2oWFN: the generated sources are now part of the distrubution.
  - The oWFN format was overworked and allows final markings.
  - GNU getopt allows more flexible command-line parameter processing allowing to create several output file formats in a single run.
  - Debug output can be written into a log file.
  - The classes organizing the Petri nets are overworked for performance and extensibility.
- fixed bugs:
  - The generation of all possible types of the `<invoke>` activity (synchronous, asynchronous, with and without implicit scope) is overworked.

Version 1.0 (16 January 2006)

- input:
  - BPEL process compliant to the specificiation BPEL4WS version 1.1, May 2003.
- output:
  - LoLA Petri net
  - open workflow net
  - Dot representation
- implemented patterns:
  - Christian Stahl. *A Petri Net Semantics fo BPEL*. Informatik-Berichte 188, Humboldt-Universität zu Berlin, July 2005.

The most recent change log is available at BPEL2oWFN's website at http://service-technology.org/files/bpel2owfn/ChangeLog.

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Version 1.3, 3 November 2008

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